Exercise	1	2	3	Total
100%	6	6	4	16
Points				

Extragalactic Astronomy and Cosmology

Homework 2 - Lecture 5 - curvature, Hubble's law

Due date: September 19

1 Angular width on a sphere

Given a sphere with radius R and a point X on this sphere. An object of width $ds \ll R$ is at fixed distance r from this point (thus, all points are on the sphere and distances are measured on the surface of the sphere). What angular width $d\theta$ will the object have seen from point X ? What happens with $d\theta$ when r approaches πR ?

Hint: If you have problems with this exercise, read Section 3.2 of Ryden

2 Drawing circles on a sphere

As in the previous exercise, imagine a sphere of radius R and work in two-dimensional coordinates. Show that if you draw a circle of radius r, the circle's circumference U will be

$$U = 2\pi R \sin(r/R) \tag{1}$$

Idealize the Earth as a perfect sphere of radius $R = 6371\,\mathrm{km}$. If you could measure distances with an error of ± 1 meter, how large a circle would you have to draw on the Earth's surface to convince yourself that Earth is spherical rather than flat?

Hint: Compare the circumference on a flat surface with that on a curved one

3 Hubble's law

Imagine four galaxies:

Galaxy A is at a distance of 10 Mpc to the East of us,

Galaxy B is at a distance of 20 Mpc to the East,

Galaxy C is at a distance of 10 Mpc to the West, and

Galaxy D is at a distance of 20 Mpc to the West.

a) Calculate their velocities relative to the Milky Way Galaxy based on Hubble's law.

b) Calculate the velocities of all these galaxies as well as that of the Milky Way, relative to Galaxy A and show that observers in Galaxy A observe the same Hubble law (i.e. that they derive the same Hubble constant H_0).